ARMY RESEARCH LABORATORY

A Statistical Study Correlating the Reported Cases of Gulf Syndrome to Battlefield Locations of Afflicted U.S. Army Personnel During the Iraq-Kuwait War Part I. Method to Relate Troop Deployment and the Reported Cases of Gulf Syndrome and Probable Incidence of Maladies Defined by the International Code of Diseases ICD-9-CM

Albert G. Gluckman

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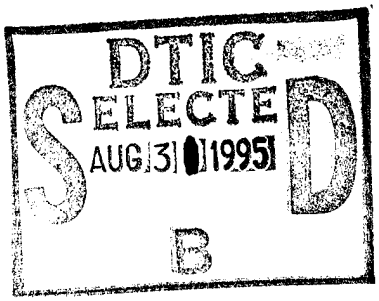

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13. ABSTRACT *(Maximum 200 words)*

The problem that this report addresses is how to relate the U.S. military grid system locations in the Kuwait-Iraq-Saudi Arabian theater of operations to the symptoms and diagnoses collectively called the Gulf War Syndrome(s). The question to be answered therefore, is whether a relation exists between a geographic location and the maladies that are medically documented? In order to solve this problem, a procedure is devised for counting the collections of symptoms and diagnoses over the various map grids of the region.

Ratios of the number of combatants reporting illness (in any grid) to the total number of combatants (occupying the grid) are discrete probabilities. These are the probabilities of the occurrence of a health condition for the total time period that a military unit occupies a grid. Also described is a method to redefine the Veterans Administration (VA) use of the International Classification of Diseases (the ICD) data classification scheme, in order to replace any arbitrary judgement on the part of a physician by a judgement that presupposes no prior possibility for the existence of a health condition that could occur prior to the combat action and which may be unrelated to the possible battlefield conditions of exposure.

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Acknowledgment is gratefully given to Dr. Josip Z. Soln for his assistance in bringing this report to completion following my retirement from Federal Service. Dr. Soln is now in command of this project, which concerns the mathematical model of the epidemiology of the Gulf War Syndrome, and certainly the effort will lead to a more adequate understanding of the serious health disorders that have afflicted too many of our service personnel who served the nation in the Persian Gulf theater of operations.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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1. INTRODUCTION

1.1 The Need for This Study. A number of Gulf War veterans have reported illness, and there are some who are totally incapacitated from exposure to some toxicant in the Saudi-Kuwaiti desert that cannot be decidedly traced to a known cause. The symptoms that these veterans experience can be an overcoming sense or feeling of weariness, which can require the administration of oxygen; pain; difficulty in breathing; the loss of the use of their legs; memory loss; irritability and uncontrolled frustration; and numbness or the loss of sensation in extremities, according to testimony given at the National Institutes of Health (NIH) conference in April 1994.* Refer to Appendix A for descriptions of the observed effects on combatants of toxic agents and exposure to radiation in the generic sense.

The threat is real: not only is the U.S. Army confronted with the problem of ill veterans who took part in the Gulf War campaign, but there is also a real future threat of some unknown aetiology that the fielded army may not be able to control in sufficient time to counter it. This may point to a need for better detection methods for various agents on future battlefields and a need for protective apparel and its easy and quick accouterment. It is also possible that what is referred to here as the Gulf War Syndrome may in fact be more than one syndrome.

1.2 Objectives of This Study. This problem will be studied from two points of view. The first is a study of the problem from the viewpoint of the geography of the conflict area, searching for biological effects whose cause or causes may be environmental and related to the geography of the conflict. This kind of a study was first made in the mid-19th century to determine the cause of cholera in London, England (Heidler 1848). The second viewpoint is that the cause of the Gulf War Syndrome is not related to the region of the conflict, but that the syndrome is caused by pharmaceutical chemicals, other chemicals, or vaccines not approved by the Food and Drug Administration (FDA).

* The Persian Gulf Experience and Health Conference, April 27–29, 1994, Clinical Center, Public Health Service, National Institutes of Health, Office of Medical Applications of Research, Federal Building, Room 618, Bethesda, MD 20892.

2. STATISTICAL METHODOLOGY: IDENTIFICATION OF VETERANS ADMINISTRATION (VA) MALADY CODES OF AFFLICTED PERSONNEL RELATED TO UNIT IDENTIFICATION CODES

In this study, we will identify the geographic locations by date of the Army personnel who served in the Gulf War and whose names are recorded in the VA register* as experiencing severe health problems. The units to which these personnel were assigned are tracked across the Iraq-Kuwait region, in order to determine whether epidemiological commonalities can be detected based upon location at certain dates.

From amongst the itemized contents found in the data table stored by the Epidemiology Service of the VA, the following items are used in this study:

OBSERVATION NUMBER	(a cardinal number)
IDENTIFICATION NUMBER	(a four-digit number identifying a person)
BRANCH OF SERVICE	(Army, Navy, Marines, Air Force)
SYMPTOM 1	(a unique string of digits recorded as a code no.)
SYMPTOM 2	(a unique string of digits recorded as a code no.)
SYMPTOM 3	(a unique string of digits recorded as a code no.)
DIAGNOSIS 1	(a unique string of digits recorded as a code no.)
DIAGNOSIS 2	(a unique string of digits recorded as a code no.)
DIAGNOSIS 3	(a unique string of digits recorded as a code no.)
UNIT IDENTIFICATION CODE (UIC)	(ARMY: The UIC is a character string consisting of a combination of letters and numbers; i.e., alphanumeric.) (MARINE CORP & NAVY: The UIC is a string of numbers preceded by a letter.)
DATE PERSON (ID NO.) ENTERED GULF THEATER OF OPERATIONS	(MM/DD/YY)

* The Veterans Administration (VA) register is maintained by the Environmental Epidemiology Service, Department of Veterans Administration, Suite 950, 1120 20th Street, NW., Washington, DC 20036-3406.

DATE PERSON (ID NO.) EXITED GULF
THEATER OF OPERATIONS (MM/DD/YY)

Absences of symptoms or diagnoses are indicated by zeros.

3. THE SYMPTOM CODES AND DIAGNOSES CODES THAT ARE SHOWN ON THE VA REGISTER

The symptom and diagnoses codes that are used in the VA register are identified as follows:

symptom codes:	ICDSYM1,	ICDSYM2,	ICDSYM3
diagnoses codes:	ICDIAG1,	ICDIAG2,	ICDIAG3

Each of these coded symptom and diagnoses elements is shown as a string of numbers. These codes are well established in the medical and public health literature ("The International Classification of Diseases" 1991; U.S. Department of Health and Human Services 1991; Davis and Stone 1990, 1991; Rogers 1994).

3.1 Description of the Code. Both the symptoms and diagnoses that are reported in the VA data table use the standard ICD*-9-CM code. Each item has a numerical designation consisting of a number from 001 for cholera, to the number 999.9, which means a health condition that is not elsewhere specified in the code. All of the decimal points have been eliminated entirely from the coded data elements in this data table so that code 780.7 is represented as 7807.

Malady information is set/put into three groupings as a procedure that is based on the criteria established by the expert panel that convened at the NIH conference in April of 1994. Accordingly, the malady information groupings are:

Criteria	Remarks About the Coded Symptoms and Diagnoses
0	malady is not used in statistical analysis.
1	coded symptom or diagnosis of malady is used in statistical analysis.

* The International Classification of Diseases.

fuzzy no. coded symptom or diagnosis of malady cannot be established as satisfying expert panel criteria, and also cannot be disestablished.

When distinguishing between criteria labeled with 1 and criteria labeled as fuzzy, the statistical analysis is called "crisp" in the first case and "fuzzy statistics" in the second case and "hybrid statistics" (Kaufman and Gupta 1985) if crisp and fuzzy numbered cases are both applied to the selection criteria. For this introductory model, only those maladies are selected that are labeled with 1, and which therefore satisfy crisp statistics.

3.2 Organization of VA Symptom and Diagnoses Data. Symptom and diagnoses data can be lumped together as a single set of six data elements constituting what can be called a symptom/diagnosis vector for each person. If any symptom or diagnosis is vacant in the vector, a 0 will appear in that vacancy, so, for example, the maladies of a person with the following information:

ICDSYM1 = 78999, ICDSYM2 = 7807, ICDSYM3 = 0
ICDIAG1 = 71940, ICDIAG2 = 0, ICDIAG3 = 0

can be shown as the information vector

[78999, 7807, 0, 71940, 0, 0]

The rationale for treating symptoms and diagnoses in the same manner is that the attending physician decides and records what are the symptoms and diagnoses of his patients. For an example of the labeling of the symptom and diagnoses data elements, refer to Appendix B.

3.3 Statistical Methodology Continued: Identification of Geographic Coordinate Locations of Army Units Using the DOD Register.* The data table stored by the U.S. Army and Joint Services Environmental Support Group contains a total of 64 data items. From these 64 items, only the UIC, the J-Date (the Julian date, a character string composed of the two-character year abbreviations together with the day of the year, i.e., 91DDD), and the MGRS (i.e., the military grid reference system) are needed.

* The Department of Defense (DOD) registry is maintained by the U.S. Army and Joint Services Environmental Support Group, Building 5089, Room 101, the Engineer Proving Grounds, Ft. Belvoir, VA 22060-5387.

The three items of data from the DOD register that are used here are:

- UNIT IDENTIFICATION CODE (UIC)

The UIC is the same as is described by the VA database. The agency that is responsible for establishing the UIC is the Defense Manpower Data Center (DMDC), with offices in Roslyn, VA, and the computation center located in Monterey, CA. The U.S. Army & Joint Services Environmental Support Group at Ft. Belvoir, VA, may have made some changes to the data format from the DMDC. The Army code is alphanumeric, and the Marine Corps and Navy codes are numerical, preceded by the letter N.

- JULIAN DATE (J-DATE)

The Julian date is a character string 91DDD, where 91 is the last two digits of the year 1991 and DDD represents the particular day in 1991.

- MILITARY GRID REFERENCE SYSTEM (MGRS)

The military grid reference system (Headquarters, Department of the Army 1993) is here set to a map scale of 10-m grids, so that the unit location is determined to within 10 m. The grid specification code that is used here consists of two letters LL followed by eight digits, i.e., LLddddddddd. For example:

a 10-m x 10-m grid may be shown as TL79806230,
a 100-m x 100-m grid may be shown as TL798623,
a 1-km x 1-km grid may be shown as TL7962,
a 10-km x 10-km grid may be shown as TL76,
a 100-km x 100-km grid may be shown as TL.

The first four digits are called the easting, and the second set of four digits is called the northing. The grid is determined from its southwest corner.

The correspondence is made between the VA data and the DOD data by unit identifiers. As a consequence of this correspondence, the sequential geographic positions of the unit under examination can be listed in progression. A progression of the geographic locations of these units by date can be plotted

to visualize their possible common geographic locations in grids on the map. This is called the mapping procedure.

4. ANALYSIS TO DETERMINE IF GEOGRAPHIC LOCATION IS RELATED TO A CAUSE OR CAUSES OF THE SO-CALLED GULF WAR SYNDROME

The easting and northing coordinates of a unit in the Kuwait-Iraq region correspond to Julian dates. For instance, the 3rd Battalion, 7th Marine regiment, entered the region on January 15, 1991, and left on February 26, 1991, being there a total of 53 days.

A military unit may be chosen from a data-sort procedure which first sorts for malady codes that describe symptoms of one of the specified possible causes of the Gulf Syndrome mentioned by the expert panel at the NIH conference.

Relationships described between units, syndromes, geographic location, and symptoms and diagnoses codes by the procedure of matching.

Malady	ICD-9-CM Code			Possible Geographically Related Causes of Maladies
$synd_1 \subset$	{set of ϕ_g}	$1 \le G$	~	effects of depleted uranium
$synd_2 \subset$	{set of ϕ_h}	$1 \le H$	~	pesticides effects
$synd_3 \subset$	{set of ϕ_i}	$1 \le I$	~	petrochemical & petrochemical smoke from fire
$synd_4 \subset$	{set of ϕ_j}	$1 \le J$	~	nerve gas and mustard gas effects
$synd_5 \subset$	{set of ϕ_k}	$1 \le K$	~	effects of Leishmaniasis infection
$synd_6 \subset$	{set of ϕ_ℓ}	$1 \le L$	~	other chemical effect

Malady	ICD-9-CM Code			Possible Causes of Maladies That Are Non-Geographic
$synd_7 \subset$	{set of ϕ_m}	$1 \le M$	~	antidote, pyridostigmine-bromide effect*
$synd_8 \subset$	{set of ϕ_n}	$1 \le N$	~	vaccines not approved by the FDA

* Points at the need for monitoring the doses of combatants on the battlefield to prevent overdose.

NOTE: Only a maximum of six ϕ terms is possible per person: a maximum of three symptoms and of three diagnoses.

The symptoms and the diagnoses that correspond to a particular syndrome represent the totality of all symptoms that are recorded by the VA as Sym(1), ..., Sym(m). There are, therefore, m symptoms, representing the totality of all the diagnoses recorded by the VA data table as diag(1), ..., diag(n). There are n diagnoses. Therefore, there are m + n symptoms and diagnoses recorded in the VA data table. Theoretically, m can be less than, equal to, or greater than n. This database, consisting of these two data tables, can be represented as the (m + n) - dimensional information vector

$$[\phi_1, ..., \phi_{m+n}] = [\phi_1, ..., \phi_j, \phi_{j+1}, ..., \phi_{m+n}]$$

where ϕ_w is some symptom or diagnosis.

The symptoms and diagnoses correspond to a particular syndrome and can be expressed as:

Syndrome 1: $\phi_q(\text{synd}_1) \ldots \phi_k(\text{synd}_1)$ where $1 \leq q \leq k \leq m + n$

Syndrome 2: $\phi_r(\text{synd}_2) \ldots \phi_s(\text{synd}_2)$ where $1 \leq r \leq s \leq m + n$

. . .

Syndrome 8: $\phi_u(\text{synd}_8) \ldots \phi_v(\text{synd}_8)$ where $1 \leq u \leq v \leq m + n$

For the case where the same symptom or diagnosis corresponds to more than one syndrome, the situation may be phrased as: If, for example, $\phi_{q+1} \sim \text{synd}_1$, and in effect, $\phi_{q+1}(\text{synd}_1)$ is true, then does ϕ_{q+1} also correspond to synd_2; and for example, can the same be said about its correspondence to synd_3, etc.?

Accordingly, a person can be represented as a collection of symptoms not to exceed three in number, and a collection of diagnoses not to exceed three in number. The information vector for a person is

$$[s_1, s_2, s_3, d_1, d_2, d_3] = [\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6]$$

Therefore, in the language of PROLOG

$$\text{person}_1(\text{ID nos.}_1) = \text{person}_1(s_1, s_2, s_3, d_1, d_2, d_3) =$$

$$\text{person}_1(\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6) = \text{person}_1(\phi_i),\ i = 1 \text{ to } 6,$$

where some of the ϕ_i can be 0.

Now, for example, to study the relation of the military unit to the person and to the symptoms and diagnoses, use the functional expression

$$\text{unit}_1 = \text{unit}_1(\text{person}_1(\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6)) = \text{unit}_1(\text{person}_1(\phi_i))$$

where ϕ_i is some symptom or diagnosis. And in the language of PROLOG, if a syndrome belongs to a symptom or diagnosis, then for example,

$$\phi_1 = \phi_1(\text{synd}_1), \text{ etc.}$$

$$\text{If } \phi_1 = \phi_1(\text{synd}_1) \text{ and } \phi_1 = \phi_1(\text{synd}_2), \text{ then}$$

$$\phi_1 = \phi_1(\text{synd}_1, \text{synd}_2) \text{ etc.}$$

The relationship of the geographic location to syndromes, symptoms, and to diagnoses can be represented by PROLOG notation as:

$$\text{geo.grid} = \text{geo.grid (date, unit)} =$$

$$\text{geo.grid (date, unit (person}(\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6)))$$

where one or some of ϕ_i can be 0.

4.1 Time-Independent Procedure to Relate Symptoms and Diagnoses, Ill Military Personnel, Military Units, and Grid Locations. Consider the functional connection of the variates

$$\text{geo.grid}^{*} \text{ (date,}^{**} \text{ unit (person } (\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6)))$$

Example.

TL 7980 6230 (91016, 13160 (1 (7807, 0, 0, 4739, 3339, 0)))

TL 7980 6230: coordinates
91016: time coordinate
13160: unit label
1: personal identity label
7807, 0, 0: symptom labels
4739, 3339, 0: diagnosis labels

Corresponding to a malady are a number of symptoms and diagnoses ϕ. Establish a chart of acceptable ϕ's corresponding to each of the acceptable maladies (refer to Appendix B). Take a count of the number of different kinds of ϕ's that are shown as labels, and also a count of the individual identity labels.

There are two procedures that are applicable to statistical analysis (crisp or hybrid). One procedure is independent of time. In this case, the totality of the units is tallied for a particular syndrome for a particular grid location. In the other case, not only is the totality of location grids tallied, but it is tallied in time sequence, so that the units are summed with respect to the interval of time (about 2 weeks) that they may occupy the same grid, for a particular syndrome. Both procedures are adopted for this epidemiological study, because each procedure lends itself to viewing the problem of syndrome dispersion over the entire Gulf War region.

Texture is fineness of resolution of grids for a case examined. For example, choose a grid texture of 100-km^2 size. Data from the DOD sample of the 3rd Battalion, 7th Marine, shows that this unit occupied

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* Meters resolution to be applied: 10 m, 100 m, 1,000 m.

** Julian date, i.e., 91016, consists of year and day of year.

the 100-km^2 grids TL, QS, and QT during the Gulf War. If we had available a corresponding VA data set of ϕ's that occupies the grids and concomitantly is connected with the unit via the UIC, then the different ϕ's could be counted per grid to give a density of ϕ's per grid; in this example. The same counting can be done for grids of finer resolution.

4.2 Method to Show for Each Grid the Relation of Military Units (Designated by the UIC) to the Enumeration of the ϕ Malady Terms. The ϕ malady terms are labels, as are the unit designations, and as are the reported ill veterans of the Gulf campaign. Let us now show a procedure to arithmeticize these labels so that they can be used in a statistical analysis. For ease of understanding, consider the following fictitious example shown in Figures 1–3.

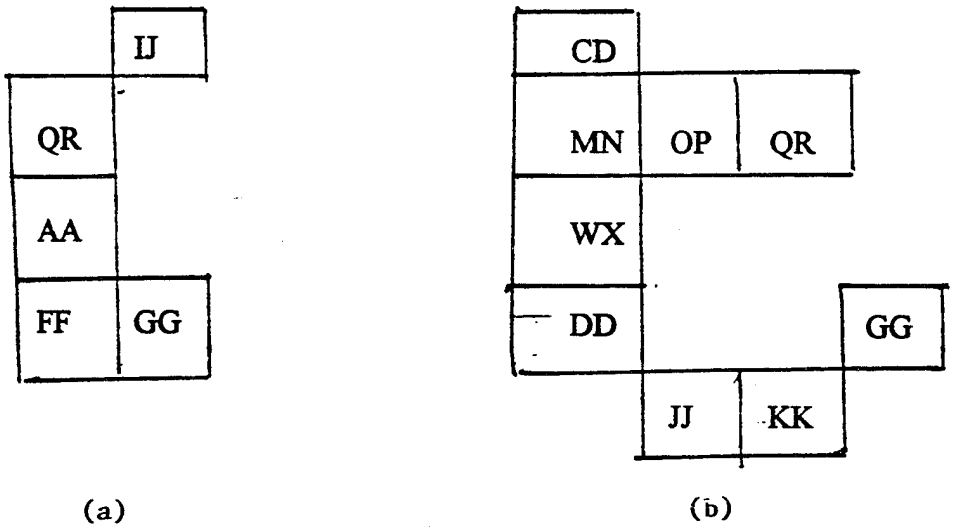

Figure 1. Grids occupied by (a) military unit 1 (UIC 1) and (b) military unit 2 (UIC 2).

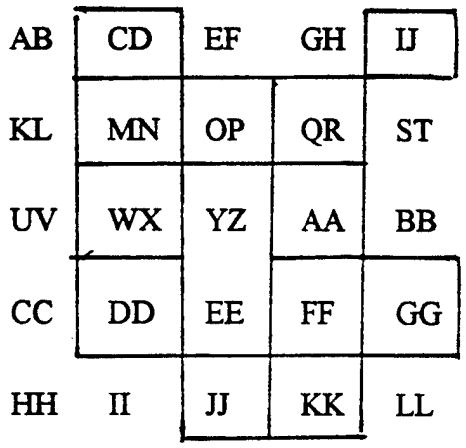

Figure 2. The pattern of grids over the entire region.

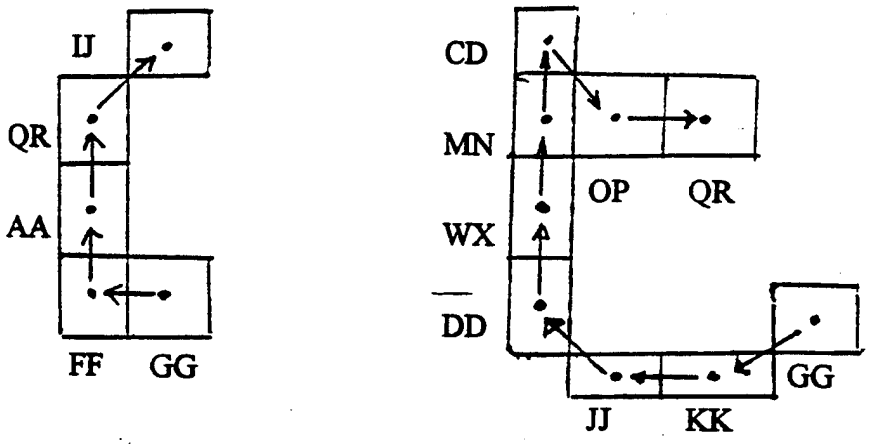

Figure 3. The paths taken by the two military units.

The grids in Figure 3 are 100 km on a side. In the study of the actual data, the grid size should be set to 100 m. Other studies of the data might require other grid sizes.

The six-vector consisting of symptoms and diagnoses is $[\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6]$. Suppose for the sake of illustration, Table 1 is a data representation.

Table 1. Crisp Statistics

Person ID No.	UIC	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	ϕ_6
1	1	1	0	0	0	0	0
2		1	0	0	0	2	0
3		0	1	0	0	3	0
4		4	1	0	0	0	0
5		1	0	0	0	0	0
6	2	5	1	6	0	7	0
7		1	0	0	0	0	0
8		1	0	0	0	0	0

The time coordinates and the northing-easting coordinates are the only ordered numbers in the data set. The ϕ_i are labels. Counts are made unit by unit of the number of different kinds of ϕ there are in a unit. No one individual (i.e., ID no.) can possess more than one of the *same kind* of ϕ, although the individual may possess more than one *different* ϕ.

Enumeration of the ϕ maladies for each UIC. For the sake of simplicity in this example, the ICD-9-CM medical codes for symptoms and diagnoses are replaced by a simple enumeration. So, for example, the VA code adaptation 7807 (of the ICD-9-CM code 780.7) is replaced by 1, and 1101 is replaced by 2, etc.

Further, a short-hand notation like 1_5 is introduced where the subscript 5 indicates the number of times that the malady 1 appears (i.e., the number of persons experiencing the malady 1), under some UIC, in a particular grid, for all time (i.e., during the time that all units have progressed throughout the Gulf region). The term 15_2 means that the malady 15 occurs twice, which means that two individuals experience the same malady in some grid location during the time spent in the Gulf region.

Therefore, Figure 4 relates the malady ϕ and some particular grid that was passed through by a unit during the entire period of time that the unit was in the region.

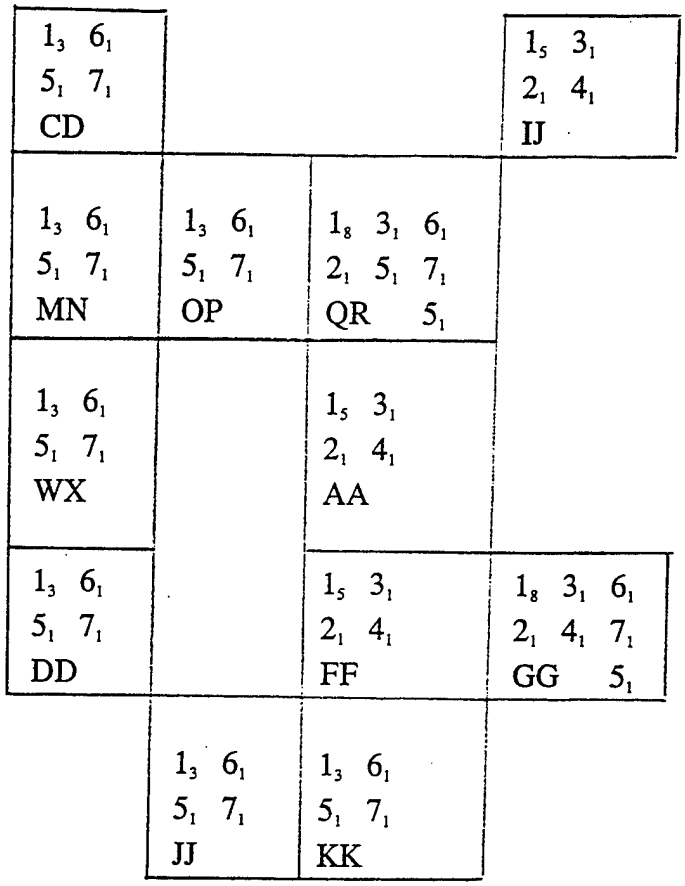

Figure 4. Sample of maladies that are enumerated inside the grid regions (crisp statistics).

When the grid size is 100 m and the number of military units is very large, the number of malady-person terms, that is $(\text{malady})_{(\text{person(s)})}$, also becomes very large.

Table 2 shows the distribution of maladies (within the framework of crisp statistics) by geographic regions at some time during the Gulf campaign. The letter pairs serve to identify the geographic regions as grid coordinates on a map.

Table 2. The Addition of Malady-Person Terms in the Previous Example

Grid GG		
UCI1	$\oplus$	UCI2
1_5	$\oplus$	$1_3 = 1_8$
2_1	$\oplus$	$0 = 2_1$
3_1	$\oplus$	$0 = 3_1$
4_1	$\oplus$	$0 = 4_1$
0	$\oplus$	$5_1 = 5_1$
0	$\oplus$	$6_1 = 6_1$
0	$\oplus$	$7_1 = 7_1$

(and so forth for all occupied grids)

Figure 5 shows the distribution of maladies (within the framework of hybrid fuzzy statistics) by geographic region traversed by the sample military units during the Gulf campaign. The letter pairs serve to identify the geographic locations as grid coordinates on a map.

Table 3 shows the relationship between individuals in the combat zones, the UIC, and the set $\{\phi\}$ of maladies.

5. ANALYSIS OF ILLNESS (MALADY) BY GRID. CRISP CASE.

Figure 6 shows the number of cases of malaise and fatigue for the particular health condition designated by the VA code as Asthenia, Lethargy, Postvirus (asthenic) Syndrome, and Tiredness. Refer to Appendix B.

Figure 7 shows probability per grid of malady. Epidemiologic conclusions can be made from these probabilities. Furthermore, a computer program can make these grids smaller at will, thus changing the distribution of the probabilities reported in the grids, as well as the values of the probabilities themselves. Various epidemiological conclusions may be made by means of this procedure.

This means that the probability is 3 to 52 that persons from UIC1 and UIC2 passing through grid OP suffer from malaise and fatigue.

HYBRID STATISTICS

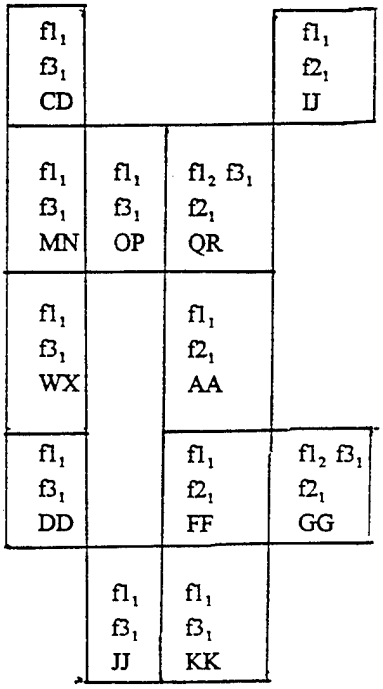

Figure 5. Sample of maladies that are enumerated inside the grid regions (hybrid statistics).

Table 3. Fuzzy Number Case

Person ID No.	UIC	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	ϕ_6
1	1	0	0	0	0	0	0
2		0	0	0	f1	0	0
3		0	0	0	f2	0	0
4		0	0	0	0	0	0
5		0	0	0	0	0	0
6	2	0	0	0	f3	0	0
7		0	0	0	f1	0	0
8		0	0	0	0	0	0

RULE: If the same code value for ϕ occurs once as a symptom and once as a diagnosis, coalesce this occurrence to a single value on the chart.

RULE: If more than one fuzzy number characterizes the same ailment according to the ICD-9-CM code, treat these numbers as distinct ϕ's because all fuzzy numbers may have different degrees of belonging to a fuzzy set.

Example.

$\phi \equiv 1 \sim$ ICD-9-CM code no. 7807

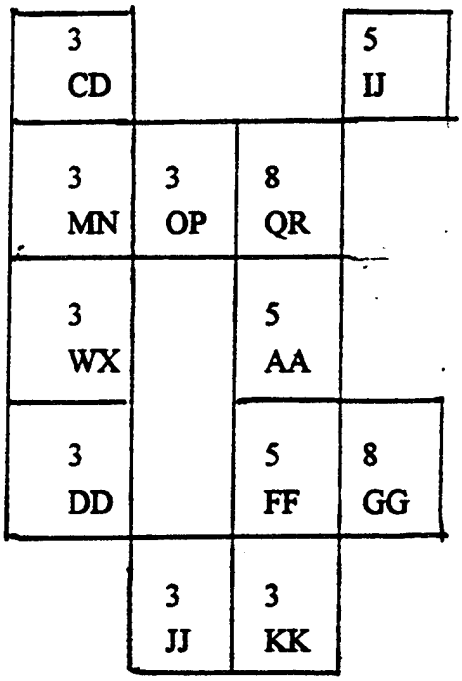

Figure 6. Number of cases of malaise and fatigue.

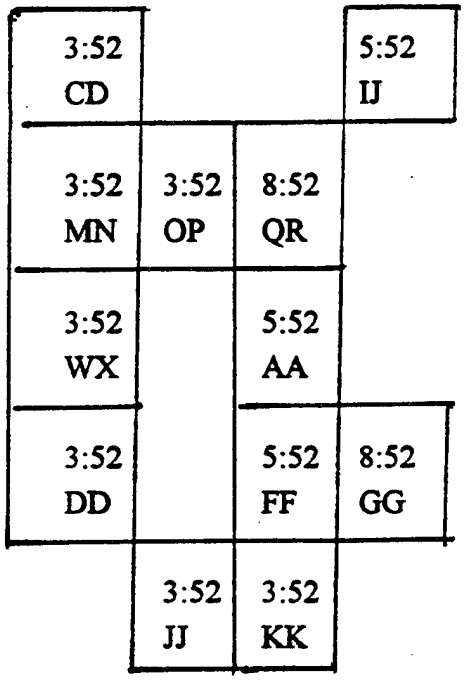

Figure 7. Kano or cases per grid to total number of cases of malaise and fatigue.

6. QUESTIONS ABOUT THE PROBABILITY RELATIONSHIPS BETWEEN PERSONS, GRIDS, SYMPTOMS, AND SYNDROMES

As part of the analysis to be performed on the VA data, an expert panel of physicians and physiologists will segregate all of the m + n reported ϕ elements into classes that are classified according to whether the ϕ elements can be symptoms associated with a particular cause. These classes $\{\phi\}$ are the collections of elements ϕ. Consequently, these collections comprise the syndromes that are associated with a cause. The same symptom ϕ may be found in more than one syndrome S (S being otherwise called a class of symptoms $\{\phi\}$).

Therefore, according to the relationships that are described in section 4 of this report, one would have, for example,

malady	Possible geographically related cause of malady
$\text{synd}_1 \equiv S_1 \sim$	effects of depleted uranium
etc.	

Now suppose that syndrome S_1 has G possible ϕ symptomatic elements. For simplicity of discussion, let G = 3. Then the ϕ elements could be, for example,

$$\phi_{12} \quad \phi_{23} \quad \phi_{97}$$

of all the m + n ϕ-elements in the complete set of ϕ's, that is, the $\{\phi\}$.

The probability P that the syndrome S_1 is found to occur in Q persons who passed through grid OP, for example, is desired. And the relationship of the probability P to the probabilities of the occurrences of the various symptoms ϕ in persons who passed through grid OP, for example, is desired, and this relationship will be the subject of further investigation.

7. THEORY OF THE SYNDROME: THE RELATION BETWEEN THE ELEMENTS Φ AND SYNDROMES

7.1 Subclasses of the Maladies $\{\phi\}$ Under the ICD Code. Consider that all of the elements $\phi \in \{\phi\}$ are classed according to the selection criteria that are discussed in section 3. This can be shown in Table 4.

Table 4. The Three Classes of Maladies $\{\phi\}$ According to Selection Criteria

Six-Vector From ICD-9-CM	Sets of ϕ Appearing in VA Data	Remarks
$[\phi_1, \phi_2, \phi_3, \phi_4, \phi_5, \phi_6]$	0 - selection criterion ϕ elements do not belong	rejected as superfluous
	1 - selection criterion ϕ elements totally belong	These statistics manipulated with crisp arithmetic
	fuzzy number describing degree of belonging of ϕ to syndrome: ϕ elements partly belong	These statistics manipulated with fuzzy arithmetic

Even though the fuzzy selection criterion describes the degree to which a ϕ (the degree is a proper fraction) belongs to the syndrome S composed of {some nos. of $\phi < m + n$}, the actual count of such is crisp.

7.2 Theory of the Syndromes Defined Over Grids. Each syndrome S is defined as a collection of ϕ, and this is symbolically shown as:

$$S \equiv \{\phi; \text{ nos. of } \phi < m + n\}$$

Suppose a 100-km by 100-km grid CD is occupied at some/any time during the Gulf War, by all those ϕ that comprise a particular syndrome S. In that case, that syndrome can be said to be present in grid CD and can be counted. But suppose that only some ϕ of any identifiable syndrome S can be identified in grid CD. Then syndrome S may be assigned a degree of belonging to grid CD, and this degree of belonging is a fuzzy number. A fuzzy arithmetical analysis can be made by adding the degrees of belonging.

The total count of a particular syndrome S over all grids in the region can be made. This count may be a combination of integral crisp numbers and nonintegral fuzzy numbers, and this count is called a hybrid number.

Likewise, in every grid in which the same syndrome S occurs, a count can be made that may be a crisp, fuzzy, or hybrid number. Discrete probability ratios can be computed for each grid (all of the grids being of the same texture) for the presence of the syndrome S from the counts that are developed by means of the PROLOG computer program. The method for counting is outlined by the example shown in Appendix C, and the counts are made for many such persons, as is shown in Figures 4 and 5 in section 4. The ratios are formed from the counts as is shown using the example in section 5.

8. NONGEOGRAPHICALLY BASED STATISTICAL SCENARIOS

The following discussion is an outline of a method for analyzing the effects of the use of vaccines that have not received approval by the FDA, and the effect of pyridostigmine bromide (used to counter the effect of nerve gases).

Those units (identified from the VA register) that report maladies are subdivided into malady groups. These malady groups are cohorts whose elements are military units (see Table 5).

Table 5. Cohorts of Units by Malady

Cohort 1 of Units	Cohort 2 of Units
[unit 1] [unit 2] [unit 3] . . .	[unit 4] [unit 1] . . .

(and so forth for all maladies). All vaccines given to member units of a cohort will be identified, as in Table 6, for example:

Table 6. Cohort 2 of Units by Malady and Vaccine

Vaccine 1. [unit 1] [unit 2]	[no. of complaints (1,1)] [no. of complaints (1,2)]
Vaccine 2. [unit 1] [unit 3]	[no. of complaints (2,1)] [no. of complaints (2,3)]

Ratio = Σ_{UNITS} (no. of complaints per vaccine) ÷ Σ_{UNITS} (total no. of vaccinated personnel)

This ratio measure is repeated for each kind of vaccine. These ratios can be examined using statistical methods.

The same method can be used to study the effects of the administration of pyridostigmine bromide to Army personnel in the Gulf region.

9. RECOMMENDATIONS

The ensuing recommendations are made to show how to complete a production model for the purpose of computing statistical measures that are concerned with the Gulf War Syndrome. These measures will enable qualified medical personnel to focus in on the probable cause or causes of the reported syndrome. These statistical measures may also yield a null result with regard to geographical locations of possible causes of a syndrome; a result which would be of paramount importance because such a result would mean that there is no connection between geography and syndrome. In addition to the present application for this method, it can be applied to other kinds of geographically related problems. Additional development of this method can improve its potential to examine this class of problems in the future.

From an epidemiological point of view, this is a retrospective study. Also, the locations of detected gas, the location of pesticide storage, and of destroyed enemy and coalition vehicles may be important with respect to determining if there is any detectable oxide from depleted uranium fragmentation.

Recommendation 1. The PROLOG matching and counting program to be worked on at the Information Processing Branch at Adelphi should be completed. This is essential to the project because the categorized

counts (i.e., tallies) of kinds of information to be processed are the raw material for the statistical formulations. These counts arise from the data in the VA registry and in the DOD data registry.

Recommendation 2. It is recommended that one surface per syndrome be described over the flat surface that is composed of grids. Such a syndrome surface will describe the distribution of the syndrome over the grid region: the surface would be viewed three dimensionally, and should appear as poles, hills, and valleys. The heights of the surface represent the amplitude of occurrence of the syndrome over a particular grid. When the grids are made smaller (i.e., are of a finer texture), the surface would express the distribution of the syndrome in finer detail.

Refer to Appendix C for a description of the handling of the time coordinates of the persons in units with respect to the time coordinates of their respective military units. In addition, mappings of examples of the grids occupied by persons during the period of their stay in the region are related to the time coordinates of their respective occupations of those grids. This description is a vital part of the PROLOG program which is to match and count the labels of the health entities (the syndromes, and the symptoms combined with diagnoses) existing in the grids. Other entities can be substituted for these in other future studies using this method of grid construction with reference to occupation of grids during periods of time.

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10. REFERENCES

Davis, J., and H. Stone. "ICD-9-CM Coding Made Easy!" Practice Management Information, 1990.

Headquarters, Department of the Army. "Map Reading and Land Navigation, Field Manual 21–26;" part 1, chap. 4: "Grids." 7 May 1993.

Heidler, C. J. Die Epidemische Cholera. Leipzig, Germany: F. A. Brockhaus, 1848.

Kaufman, A., and M. M. Gupta. Introduction to Fuzzy Arithmetic: Theory and Applications. New York: Van Nostrand Reinhold Co., 1985.

Rogers, G. (editor). "ICD-9-CM Diagnosis Codes Required by Medicare and Most Insurance Companies." Practice Management Information, October 1994.

The International Classification of Diseases. Fourth edition, 9th revision, Clinical Modification ICD-9-CM, vol. 1, October 1991.

U.S. Department of Health and Human Services, Public Health Service. Health Care Financing Administration. DHHS Publication No. (PHS) 91-1260, 1991.

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APPENDIX A:

SYNOPSIS OF RELEVANT REPORTS CONCERNING
THE GULF SYNDROME THAT WERE DELIVERED
AT THE CONFERENCE AT THE
NATIONAL INSTITUTES OF HEALTH
IN THE SPRING OF 1994

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Categorization of the maladies. According to expert medical testimony given at the *Technology Assessment Workshop on the Persian Gulf Experience and Health*, a conference that was recently held at the National Institutes of Health (NIH) in Bethesda, MD, there are a number of possible distinct causes for the Syndrome; in other words, a single syndrome may consist of multiple causes. It is also possible that two or more syndromes are being observed. These possible distinct causes are now described.

REPORT OF VA EPIDEMIOLOGY SERVICE ON TYPES OR CLASSIFICATION OF SYMPTOMS.

(i). *Report by Dr. Han K. Kang, Nancy A. Dalager, and Kevin K. Watanabe.*[*] The Epidemiology Service of the Veterans Administration (VA) is statistically classifying the ailments of veterans of the Desert Storm campaign that have been recorded during physical examinations.

REPORT ON URANIUM MEDICAL EFFECTS ON MAN.

Depleted uranium (DU). It has been suggested that the DU used in American aircraft projectiles, ground weapon artillery, tank projectiles, and armor plating could be a cause of the Syndrome. The entry of uranium material into the human body could occur as ingestion or inhalation of uranium oxide dust or powder existing in the vicinity of damaged or destroyed enemy vehicles and artillery pieces, or from fragmentation chips of DU entering the human body as a result of enemy fire shattering armor plates on armor-clad American vehicles.

After a chemical explosion of projectiles containing DU, a fine uranium oxide dust can be left as residue that can be inhaled into the lungs. Such a dust can be primarily chemically toxic to the kidneys if it is ingested in exposed food and water. The principal concern in this case is with uranium poisoning from chemical toxicity to the kidney as the principal target organ.

However, the low lvel of radiation can not be responsible for any health effects observed in the short term. And the effects from fragments imbedded in human flesh could only be a long-term effect taking place over many years. The number of soldiers who have experienced uranium shrapnel is minute in

[*] The Veterans Administration (VA) register is maintained by the Environmental Epidemiology Service, Department of Veterans Administration, Suite 950, 1120 20th street, NW., Washington, DC 20036-3406.

relation to the number of cases who are reported to be experiencing medical problems of the kinds that are ascribed to the Gulf War syndrome.

(ii). An assessment by E. G. Daxon* of the effects of DU on humans. DU is used by U. S. military forces in antitank munitions and in tank armor.

natural uranium consists of the isotopes:

α, β, low energy γ, x-ray

According to Daxon,

"The radiation exposure is primarily from the small fraction of high-energy γ radiations and x-rays . . . "

He also stated that

"The DOD conducted an extensive series of studies to quantify the radiation exposure received by personnel during the transportation, storage, and use (loaded on the tank or aircraft) of DU-containing systems. These studies found that the exposures were such that, with the exception of warehouses where large quantities of DU munitions were stored, the estimated annual exposures did not exceed the current standard of 100 mrem/yr . . . "

"Internalization of DU can occur on the battlefield as a result of fires involving DU munitions, a DU munition striking an armored target, or working in a vehicle contaminated with DU. In general, only a small fraction (less than 1%) of DU particulates from storage or tank fires were respirable and greater than 90% of the respirable particulates were insoluble. When a DU munition strikes an armored target the fraction of particulates generated that are respirable ranges from 50% to 90%. Approximately 17%–48% of the respirable particles are soluble in lung fluid[;] the remainder are insoluble."

* Eric G. Daxon, Ph.D., LTC, DU Exposures During the Persian Gulf War (27–29 April 1994 Conference at NIH). Armed Forces Radiobiology Research Institute, Bethesda, MD 20889-5603.

"Estimates based on simulated bulk storage fires, test fires involving vehicles uploaded with DU munitions, and tests in which DU munitions struck armored vehicles showed that the potential for inhalation of DU in excess of current safety standards exists only inside vehicles when they are penetrated by DU munitions. Our Persian Gulf experience showed that DU can also be internalized through wound contamination and the injection of DU fragments."

"As a result of unfortunate friendly fire incidents involving DU munitions, 36 U.S. soldiers were wounded, with 22 of them suspected of having retained fragments that were potentially DU. For each case, standard surgical criteria were used to determine whether the shrapnel was not removed because the number and locations of these fragments made the risks of surgery significant."

It was found that there were "sufficient uncertainties with the potential chronic effects to warrant long term follow-up of patients with fragments and to conduct research."

Analysis by E. G. Daxon of the Radiation Effects of DU

1. Military uses of DU. Penetrators, armor, ballast in aircraft

A. Combat use of DU. (i) Combat vehicle exposure rate: 100% DU munitions have less than 0.5 mrem/hr; (ii) Mix of DU and non-DU has probable maximal exposure rate of less than 0.09 mrem/hr.

B. External exposure rates in bulk storage facilities. Exposures in the range of 1 to 2 mrem/hr.

C. Uranium air sampling results from tests of penetrator strikes of DU armored vehicles.

(a) Outside vehicle, 0.3 mg uranium uptake at 30 m.
(b) Outside vehicle, 0.0008 mg at 200 m.

D. Uranium urine analysis to date (April 1994) of fragment patient population.

Six personnel had readings above 2 µg/liter; the highest reading is 30 µg/liter.

E. DU contamination studies. Vehicle fire with uploaded DU munitions.

F. Skin contact exposure to bare DU penetrators. Contact skin dose rate is 200 mrem/hr.

G. Areas for future research. (i) chronic chemical toxicity, (ii) chronic radiation exposure.

REPORT ON PETROCHEMICAL EFFECTS ON MAN

(iii). Petrochemical smoke. *(1) Report of Nelson S. Irey, M. D.* 14 March 1994.*

(a) Dr. Irey reported the results of autopsies of 85 casualties of the Kuwait theater of operations, whose remains were examined for evidence of disease that might be ascribed to smoke from over 600 oil well fires set by the retreating Iraqi forces.

> " . . . the morphologic findings on the smoke era group failed to reveal evidence of acute necrosis in lungs, liver and kidneys. The thirty cases in the pre-smoke era (control group) showed no pathologic changes other than those that supported the diagnoses as listed in the preceding diagnosis table. Thus, there is no evidence in this study to support morphologic smoke-related damage in these Kuwait smoke-era deaths."

(b) *Report of the toxicologic studies made on samples of blood from the same 85 casualties as in (a) above*, as reported by Victor F. Kalasinsky, Ph.D.**

> "Blood specimens were analyzed for metals using standard atomic absorption methods, and concentrations are reported at the parts-per-million (ppm) or parts-per-billion (ppb) levels. The metals chosen for this study include those expected from dietary sources (copper, zinc), those expected in crude oil (nickel, vanadium), and toxic heavy metals (cadium, chromium, lead)."

. . .

* Nelson S. Irey, M. D., Chairman, Department of Environmental and Toxicologic Pathology, Armed Forces Institute of Pathology, Washington, DC 20306-6000.

** Armed Forces Institute of Pathology, Washington, DC 20306-6000.

The following generalizations can be drawn from the preceding toxicologic data:

1. The extremely high concentrations of metal found in some blood specimens suggest that contamination occurred during sample collection or storage.

NOTE: This is an hypothesis.

2. The vast majority of metal concentrations in blood were in acceptable ranges. Of particular importance were vanadium and nickel metals which are in crude oil in relatively large quantities.

3. Metal analysis does not indicate any serious, irreversible, long-term exposure to smoke/soot from the oil-well fires.

NOTE: The word "serious" is here interpreted to mean significant.

Glossary of cause of death of smoke-era casualties (excluding pre-smoke era casualties)

accidents	11
gunshot suicide	2
drug overdose	1
homicide gunshot	1
accident gunshot	1
killed in action	3
cause undetermined	1
cardiovascular disease	8
meningococcemia	1
pneumonia	1
TOTAL	30

(2) Studies made of the oil well fire fighters at the University of Texas.

Studies made by Gary Friedman, M.D., of the University of Texas School of Medicine, have shown no ill effects in any of the Kuwait theater fire fighters who were examined. According to informed medical

opinion as a consequence of Dr. Friedman's studies, petrochemical smoke may not be a principal concern as a cause of the Gulf syndrome. Needless to say, long-term effects on the lungs and eyes and mucous membranes can be a consequence of exposure to petrochemical smoke if directly or indirectly exposed.

Report of Gary K. Friedman, M.D.[*]

"In February 1991, Iraq purposefully detonated explosive charges damaging or igniting 749 wells in Kuwait's oil fields in addition to setting fire to storage tanks, refineries, and similar facilities. Each well burned up to 80,000 barrels per day with flares up to 700 ft in height and smoke plumes reaching 12,000 ft. The smoke was generated at an estimated 400,000–500,000 tons per week and contained particulate matter, gases (H2S, SO2 etc.), volatile organics, PAH's, etc. The highest readings for these gaseous and particulate materials were recorded from measurements taken in the smoke plumes in the oil fields (U.S. Interagency Air Assessment Team in Kuwait and Saudi Arabia). The following represents the current health status of a cohort of fire fighters responsible for extinguishing the Kuwait oil fires exposed to these high concentrations. A brief correlation with relevant domestic civilian experience also is discussed. The majority of the fires were extinguished by the cooperative efforts of three Houston, TX based companies experienced in battling oil well fires."

"Efforts to control the fires began in late February 1991 while hostilities still raged in Southern Iraq. The last well was extinguished and crew departed November 1991. Crews worked 10–12 hr days averaging 29–40 day tours of duty alternating with 21–28 day periods of leave. Most of the Adair team activity involved the Al Bergan oil field and the Al Ahmadi Oil Field. The Adair Co. sent 3 teams of 10 fire fighters plus support crew including cooks and medics. The other companies had similar contingents."

"Protective gear: Nomex underwear, face mask, gloves, hard hat, leather boots, work coveralls. No respiratory protection."

NOTE: The Adair Co. extinguished 118 oil well fires.

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[*] Texas Occupational Medicine Institute, 11757 Katy Freeway, Suite 1540, Houston, TX 77079.

"Living conditions: Within 2 miles of burning fields between the Bergan and Ahmadi fields. Buildings initially had no running water or air conditioning; . . . smoke filled building."

"Toward the end of campaign a compound was established at Ahmadi where conditions were better as fires [were] brought under control. 500–600 inhabitants[.]"

"Personnel: Most were over age 30. Most had 10 or more years experience (some 25+ years) fighting similar fires. Many had previously fought fires in Kuwait, Saudi Arabia, Iran, Iraq, Dubai, Bahrain, etc."

"Medical surveillance: As Head of Occupational and Environmental Medicine at University of Texas Medical School, Houston, the Texas Lung Institute and Toxic Fume Center, I was asked to examine each member of the Red Adair Co. before and after each tour of duty in Kuwait. I subsequently gathered data from Wildwell Control Inc. and Boots and Coots, the other companies from the Houston contingent."

"Medical testing:

1) Complete history and physical
2) CBC
3) SMA - 20 (glucose, BUN, Creat, Uric acid, even enzymes, etc.)
4) Pulmonary function test (spirometry)
5) Chest x-ray
6) EKG
7) Stool for O & P (as available)
8) Urinalysis
9) Additional testing as indicated"

"On return, note was made of any illness or symptoms during the prior tour."

"Results: In all the above cohorts we have not seen a syndrome similar to that currently under study."

"Opinion: While a "Desert Storm Syndrome" has yet to be succinctly defined or its specific diagnostic criteria identified, those claiming such an illness would appear to have had far less exposure to any toxic component of the fires than those who worked and lived in the burning oil fields themselves. This fact is further amplified by the fact that the fire fighters had fought similar fires for years and yet neither they or their comrades experienced such an illness nor does a thorough review of the literature indicate that such has ever been previously reported."

"The similar absence of such findings among thousands of union members spending a working lifetime in the oil fields, refineries, and petrochemical plants of East Texas and West Louisiana, leaves me with the conclusion that if a 'Desert Storm Syndrome' is defined, that raw or burning crude oil should be dismissed as a probable etiology."

REPORT ON NERVE GAS AGENTS AND MUSTARD GAS

(iv). Chemical warfare agents such as nerve gas and mustard gas. *Report of Mr. Dennis Ross, "Gulf War Syndrome as an Intelligence Question,". Defense Intelligence Agency.*[*] According to Mr. Ross:

"Immediately after the [Persian Gulf] war, a massive effort to collect and destroy remaining Iraqi equipment throughout occupied Iraq and Kuwait began. Not one chemical or biological munition, nor any bulk agent, has been found in occupied Iraq or Kuwait as a result of that effort."

The primary U.S. contractor for unexploded ordnance removed in Kuwait stated recently that to date [as of April 29, 1994], although more than 15,000 tons of all types of ordnance have been removed, including 350,000 mines, no chemical-biological warfare (CBW) weapons have been found and no personnel in the Gulf were treated for exposure to CBW.

"Standard operating procedure to determine the presence of CW agents requires a two step process involving 1) detection and 2) confirmation. In the detection phase, automatic detectors alert troops by sounding alarms. Because the equipment is very sensitive by design, false alarms are often registered. This was the case during the Gulf War. Despite a large number of initial detections,

[*] Defense Intelligence Agency, Bowling Green Air Force Base, Washington, DC.

however, the second step, confirmation, using equipment and techniques available at the platoon level, never resulted in a single confirmation of CBW during the Gulf War."

"In addition to all the unconfirmed detections investigated and registered as false alarms, a variety of soil, liquid and air samples suspected of containing CW agents were analyzed at state-of-the-art labs in the U.S. and UK. These samples were taken before, during and after the war from suspected "hot" areas in Saudi Arabia, Kuwait and Iraq. The results from all samples tested were negative. Likewise, air samples checking for the presence of Biological Weapons (BW) agents were continuously taken and analyzed at state-of-the-art labs. As with the CW samples, all tests for BW agents were negative."

"Only . . . the . . . Czech reports of CW detections on 19 and 24 January 1991, appear to be credible. The U.S. cannot independently verify the Czech detections, but places a measure of confidence in their findings, based on recent assessments of their technical competence and the sensitivity of their equipment. On the 24th, the Czechs found what appeared to be a localized puddle of Mustard Gas, origin unknown, in the desert near King Khalid Military City. There was absolutely no evidence of Iraqi military activity in the vicinity. On the 19th, the Czechs reported detection of extremely low levels of a nerve agent in very localized areas near Hafar Al Batin. Again, there was no evidence whatever of Iraqi military activity. According to the Czechs, the nerve agent detected on 19 January was present for less than forty minutes. . . . no other units in the area detected the nerve agent."

"A popular theory which appears at first to be borne out by the Czech detection suggests . . . long term exposure of our troops to low, i.e., undetectable, levels of CW. This, however, would appear unlikely for several reasons. The . . . Law of Diffusion states that any gas or liquid . . . moves from greater to lesser concentration. Consequently, if, in one area or time, the concentration of CW is low -- as in the Czech detection -- at some other area or previous time the concentration must have been high. Therefore, other detections would be expected nearby, possibly resulting in casualties. This did not happen even though other Coalition units were in contiguous areas."

"An alternate explanation for long term low level exposure below detection range would appear to be the deliberate, CONTINUOUS release of very small amounts of agent throughout the area where troops were to have been exposed. This would have included much of . . . [Saudi Arabia]

because, rather then localized in one area, cases of the . . . illness have been reported by veterans stationed throughout Saudi Arabia. If this were the case, . . . [Saudis] would also have experienced and reported these symptoms."

"Another . . . theory holds that the Czech detection resulted from CW agents released when Coalition Forces bombed Iraqi targets. We estimate that under ideal conditions, 80 tons of nerve agent would need to have been instantaneously released from the closest bombed target, An Nasiriyah -- 140 miles north of Hafar Al Batin -- in order to register at the low levels detected by the Czechs. Such an 80 ton release of nerve agent in Iraq would have resulted in an area of certain death or casualty that covers hundreds of square miles. Moreover, detection equipment throughout the area would have sounded an alarm and additional confirmation would have been expected. None of this happened."

"Even a release caused by a bomb from coalition aircraft striking a secondary target -- perhaps an unknown CW storage site or convoy near the border for example -- would have been subject to the Law of Diffusion. People nearby would have died or become casualties, detection alarms would have sounded and confirmations would have been expected. None of this happened."

"In addition to the Law of Diffusion, weather conditions further argue against the theory that the Czech detections were a result of Coalition bombings of targets in Iraq. The winds at the time were in the wrong direction -- from the southeast blowing to the northwest back into Iraq -- and it rained throughout the region the day before the Czech detection."

"COMMENT

[If the Czech detections] are accepted as valid, what was their source? The low concentration and short duration of the detection on the 19th, the extremely localized area affected, the meteorological conditions, the absence of other detections by other units nearby, the topography of the area and the fact that no military action took place anywhere near the area, all suggest a SINGLE release of a very small amount of agent. Regarding the puddle of Mustard Gas encountered by the Czechs on the 24th, its origins are equally mysterious . . . the most logical [of] explanations for either incident would seem to be possible live agent tests of the Czech equipment, or possible accidents involving chemical agents among Coalition Forces. There is a paucity of evidence to prove either explanation . . . "

(v). U.S. Army pesticide chemical agents. *Report of Captain Herbert T. Bolton, Medical Service Corps, U.S. Navy, Armed Forces Pest Management Board.*[*]

According to the Bolton report, there are no "application records for pesticides used" in the Kuwait-Saudi theater of operations. The "quantities of repellents and pesticides that were requisitioned [and returned] through the supply system" are recorded. This inventory of pesticide stock does not account for:

(a) repellents and pesticides in the inventories of military units prior to the Gulf War;
(b) repellents and pesticides given to the Kuwaiti and Saudi Arabian governments.

NOTE: Military pesticides issued through the Pest Management Board authority are Environmental Protection Agency (EPA) registered.

primary repellents

(a) 33% DEET (N, N-diethyl-m-toluamide) cream applied to skin (effective up to 12 hours)
(b) 0.5% permethrin aerosol applied to battle uniform which is worn when the uniform is dry

NOTE: DEET has been in use since 1957 and is estimated to be used annually "by 50 to 100 million people per year."

NOTE: Permethrin is approved by the Food and Drug Administration (FDA) for head lice and scabies control in addition to its registration as a pesticide.

[*] Executive Director, Armed Forces Pest Management Board, Forest Glen Section, Walter Reed Army Medical Center, Washington, DC.

secondary repellents

(a) In lesser quantities, the Corps distributed two "other EPA registered DEET formulations."

(b) A benzocaine/sulfur product.

other repellents used that were not issued and are not formulations of DEET

(a) 6-12 (ethyl hexanediol). This ingredient is EPA registered, but not as effective in pest control as the repellents issued by the DOD.

(b) "Skin-So-Soft." This commercial product is not registered with the EPA as a pesticide. This product/compound provided "a mechanical barrier to biting insects."

(c) Pet flea and tick collars registered by the EPA are "only for use on domestic pets." Some brands contain an organophosphate, and their use is not condoned by the DOD.

NOTE: "If the pet collars are worn on the calves of the legs or elsewhere on exposed skin, irritation of the skin can occur." Their use was prohibited by order.

repellents used by local Saudi contractors

(a) "Local [Saudi] contractors working for local public health departments [around some Saudi housing areas] did apply pyrethroid insecticides as ultra low volume aerosols."

(b) "Local contractors applied residual sprays of malathion to portable latrines."

purchase of insecticide bait and residual insecticide in Saudi Arabia by some U.S. units

(a) "These contained the active ingredient azamethiphos, an organophosphate insecticide."

(b) "The bait is a combination of an attractant with an insecticide . . . dispensed in containers."

aerosol-formulated insecticide used in the Gulf War region

d-phenothrin	(used most)
chlorpyritos	(ultra-low volumes)
resmethrin	(ultra-low volumes)
malathion	(residual application)
bendiocarb	(residual application)
cypermethrin	(residual application)
propoxur	(residual application)
methomyl	(fly control baits)

NOTE: Ultra-low volumes: pyrethroids

rodenticides: brodifacoum, bromadiolone, diphacinone, chlorophacinone, warfarin
a fungicide
a fumigant
delousing powder: 1% lindane
flea control: carbaryl dust
other: azamethiphos

The report concludes that there were no reported cases of pesticide poisonings; and further, "based on pesticides supply records, there were no pesticides requisitioned that would lead to exposure different from what U.S. military personnel would typically encounter in the U.S. . . . ."

REPORT ON THE LEISHMANIASIS INFECTION

(vi). Leishmaniasis. *Report of A. J. Magill, M. D., "Leishmaniasis as a Potential Cause of the Gulf War Syndrome."*[*] According to A. J. Magill, M. D., The Gulf War Syndrome [GWS] is:

[*] The Persian Gulf Experience and Health Conference, 27–29 April 1994. Address: A. J. Magill, M.D., Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington, DC 20307-5100.

"A chronic illness in veterans of Operation Desert Storm (ODS), characterized by fatigue, arthralgias, gastrointestinal symptoms and neuropsychiatric complaints . . . Whether GWS is a distinct clinical entity causally related to ODS or a heterogeneous collection of illnesses without relationship to ODS is controversial."

He defines Leishmania as:

"obligate intracellular parasites of mononuclear phagocytes, [having] . . . a long incubation period (months to years), [that] can lead to infection, and cause a variety of diseases in which the clinical outcome of recognized syndromes . . . depends on the immune response of the host." Magill remarks that "Viscerotropic leishmaniasis (VL) is a newly recognized clinical syndrome identified in veterans of ODS."

Hypothesis of Magill. From his studies on Leishmaniasis, Magill hypothesizes that a

"small number of *Leishmania* parasites may initiate a cellular immune response with a "cytokine release" phenomenon causing chronic illness."

Table C. Models of response to the parasitic organism Leishmania

cutaneous leishmaniasis

disseminated cutaneous leishmaniasis (DCL)	• resembles lepromatous leprosy
mucocutaneous leishmaniasis (MCL)	• ulcerative lesions of the nasal, oral, or pharyngeal mucosa
kala-azar	• response similar to lepromatous leprosy

similar response models (using Ridley-Jopling classification for leprosy: a host immune response characterization)

		characterized by:
Mycobacterium leprae	(1) Lepromatous leprosy	(a) high numbers of mycobacteria (b) absent cell mediated immune response (c) easily detectable by ineffective antibody response (IFA)
	(2) Tuberculoid leprosy	(a) very few mycobacteria (b) strong cell mediated immune response (c) no detectable antibody response
	(3) Intermediate forms	(a) degree of cell-mediated response of leprosy varies

REPORT ON VACCINES AS A POSSIBLE CAUSE OF GULF WAR SYNDROME

(vii). The use of vaccines.[*,**] Vaccines that were not approved by the FDA for use in the general population.

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[*] Franz, D., L. Pitt, M. Clayton, M. Hanes, and K. Rose. "Efficacy of Prophylactic and Therapeutic Administration of Antitoxin for Inhalation Botulism." Proceedings on Botulinum Tetanus Neurotox. Edited by B. R. Dasgupta. New York: Plenum, pp. 473–476, 1993.

[**] Friedlander, A., S. Welkos, M. Pitt, J. Ezzell, and P. Worsham. "Postexposure Prophylaxis Against Experimental Inhalation Anthrax." Journal of Infectious Diseases, vol. 67, pp. 1239–1242, May 1993.

REPORT ON POSSIBLE OVERDOSE USAGE OF PYRIDOSTIGMINE BROMIDE AND EFFECT ON MITOCHONDRIA AND TOXICITY OF NEUROMUSCULAR JUNCTIONS

(viii). Pyridostigmine bromide.* *Report by C.S. Hudson, R.E. Foster, and M.W. Kahng***

Assessment of Pyridostigmine bromide administration on neuromuscular junctions (NMJs) for three different muscles of male albino rats.

muscles	fiber type
diaphragm	type I & type II
soleus	type I predominates
extensor digitorum longus	type II predominates

RESULTS OF EXPERIMENTATION

(1) whole blood cholinesterase (ChE) depression of approximately 60-70% as determined by radiometric assay

(2) exposures/administration "resulted in morphological alteration of neuromuscular junctions (NMJs) of all three muscles"

(3) ". . . the most frequently observed presynaptic alterations were [a] mitochondrial damage and [b] partial withdrawal of nerve branches (partial denervation)."

postsynaptic changes

(1) "occasional rarefaction of mitochondrial matrices"

(2) "disruption of the myofibrillar organization in small numbers of subjunctional sacromers."

---

* Foster, R. E., C. S. Hudson, and M. W. Kahng. "Neuromuscular Toxicity of Pyridostigmine Bromide in the Diaphragm, Extensor Digitorum Longus, and Soleus Muscles of the Rat." Fundamental and Applied Toxicology, vol. 5, pp. 260–269, 1985. (Robert Foster is in the Neurotoxicology Branch, Physiology Division, U.S. Army Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD 21005.)

** Department of Pharmacology and Experimental Therapeutics, Schools of Medicine, University of Maryland, Baltimore, MD.

"The variability [of observed changes] appears random and not related to a specific fiber type or dosage regimen."

REPORT ON COORDINATION ACTIVITIES OF AGENCIES

(ix). Coordination of the VA and DOD agencies in their efforts to understand the cause or causes of the Gulf War Syndrome. *Report of R.H. Roswell, M.D.*[*]

The VA is organizing its efforts as a triad of activities. They are (1) medical care, (2) research, and (3) disability compensation.

(a) Medical care. The VA has developed two registries: (1) the Persian Gulf Oil Fire Registry and (2) the Persian Gulf Registry established under Public Law 102-585 that was enacted in November of 1992. As of April 4, 1994, 16,000 veterans have participated in voluntary health examinations as part of the registry.

(b) Research.

Research Advisory Panels.

The VA established an advisory committee on health consequences of service in the Persian Gulf to make reviews and recommendations concerning current and future research directions for that agency. In addition,

> "With Congressional authorization, the Departments of Veterans Affairs and Defense have jointly contracted with the Medical Follow-up Agency of the National Academy of Sciences to review scientific and other information on the health consequences of military service in the Persian Gulf during the Gulf War. The agreement calls for recommendations concerning the adequacy of actions taken to monitor health consequences of such service, as well as the need for epidemiological studies."

---

[*] Chief of Staff, Executive Director, Persian Gulf Veterans Coordinating Board, Department of Veterans Affairs, Medical Center, 700 South 19th Street, Birmingham, AL 35233.

Environmental hazard exposure. The regional office of the VA at Louisville, KY, will be in charge of this effort. However,

> "The Department of Veterans Affairs is also in the process of creating up to three Environmental Hazards Research Centers. The centers will address . . . physiological and psychological effects of chemical and biologic exposures . . . Medical centers were asked to submit proposals for peer review by March 31, 1994, with funding scheduled to begin in July."

Chronic fatigue syndrome (CFS). This effort is primarily the responsibility of the Centers for Disease Control and Prevention.

(c) Disability compensation.

> " . . . approximately 3,300 veterans have filed claims for disabilities believed to be the result of such an exposure [that is, environmental hazards exposure]. Service connection has been allowed to 260 veterans, while nearly 1,800 claims are in various stages of developing evidence, and another 142 claims were ready to be decided [apparently] as of April 4, 1994."

With regard to all disabilities:

> "As of April 4, 1994, approximately 300,569 Gulf War participants had been discharged from the military and nearly 35,000 veterans have filed disability claims . . ."

Decisions were made "in 28,287 claims, and over 9,288 veterans are receiving disability payments."

APPENDIX B:

DICTIONARY OF MALADIES OF SAMPLE FROM VA EPIDEMIOLOGY SERVICE

INTENTIONALLY LEFT BLANK.

A numeral 1 in the criteria column means this malady fits the criteria of possible causes of the Gulf War Syndrome that are described in Appendix A. A numeral 0 in that column means that this malady does not fit the criteria of the possible causes of the Gulf War Syndrome that were described and discussed by the panel of experts at the NIH conference in April of 1994. A fuzzy number from fuzzy set theory in the criteria column means that the symptom or diagnosis may or may not be related to the criteria, and if it is, it may be related to some degree.

The VA code is an adaptation of the V code where the decimal point has been disregarded for the purpose of making it easy to use as a computer code. The V code is one of several medical codes that are internationally recognized, and is the usual code that is used by a physician for insurance and other purposes. The V code describes the illness in detail. The term ICD code that is used here is an abbreviation of ICD-9-CM. The ICD-9-CM is a compendium of all the medical codes that are used by the medical and allied professions to describe disease.

VA Code	ICD Code	V Code	Criteria	Description of Malady
V133		V13.3	0	*Diseases of skin and subcutaneous tissue* (personal history of other diseases)
V728		V72.8	0	*Other specified examinations* (preoperative)
311	311		fuzzy	*Depressive disorder, not elsewhere classified*
496	496		fuzzy	*Chronic airway obstruction, not elsewhere classified* Chronic: nonspecific lung disease, obstructive lung disease, obstructive pulmonary disease
1101	110.1		1	*Dermatophytosis* Infection by species of Epidermophyton, Microsporum, and Trichophyton tinea of nail: Dermatophytic onychia, Tinea unguium, Onychomycosis
2166	216.6		0	*Skin of upper limb, including shoulder* (benign neoplasm of skin)
2859	285.9		fuzzy	*Anemia, unspecified* Anemia: essential, normocytic - not due to blood loss or iron deficiency; Anemia: profound, progressive, secondary; Oligocythemia.
4739	473.9		fuzzy	*Unspecified sinusitis (chronic)* Sinusitis (chronic)

4781	478.1	0	*Other diseases of nasal cavity and sinuses* (Abcess, Necrosis, Ulcer) of nose-septum, cyst or mucocele of sinus (nasal), Rhinolith
5589	558.9	1	*Other and unspecified noninfectious gastroenteritis and colitis* Colitis, Diarrhea, Enteritis, Gastroenteritis, Ileitis, Jejunitis, Sigmoiditis (Colitis can be caused by Clostridium Difficile infection.)
6929	692.9	1	*Unspecified cause for inflammatory conditions of skin and subcutaneous tissue* Dermitis: contact, venenata, Eczema
7061	706.1	0	*Other acne* Conglobata, cystic, pustular, vulgaris, blackhead, comedo
7242	724.2	0	*Lumbago* Low back pain, Low back syndrome, Lumbalgia
7291	729.1	1	*Mylagia and myositis, unspecified* Painful muscles, inflammation of muscles
7804	780.4	fuzzy	*Dizziness and giddiness* Light-headedness, Vertigo (EXCLUDES Ménière's disease & other specified vertiginous syndromes)
7806	780.6	1	*Pyrexia of unknown origin* Chills with fever
7807	780.7	1	*Malaise and fatigue* Asthenia, Lethargy, Postviral (asthenic) syndrome, Tiredness
7808	780.8	1	*Hyperhidrosis* Diaphoresis, Excessive sweating
7809	780.9	1	*Other general symptoms* Amnesia (retrograde), Chills, Generalized pain, Hypothermia not associated with low environmental temperature
7819	781.9	0	*Other symptoms involving nervous and musculoskeletal systems* Abnormal posture
7821	782.1	0	*Rash and other nonspecific skin eruption* Exanthem

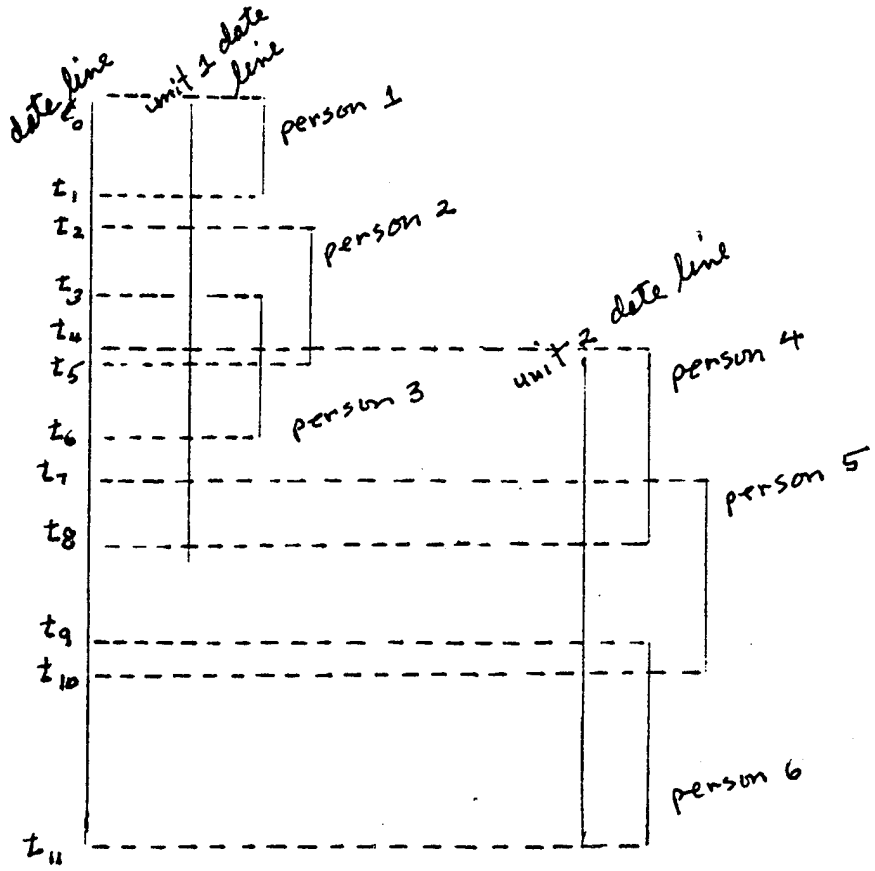
7822	782.2	0	*Localized superficial swelling, mass, or lump* Subcutaneous nodules
7831	783.1	0	*Abnormal weight gain*
7840	784.0	fuzzy	*Headache* Facial pain
7859	785.9	fuzzy	*Other symptoms involving cardiovascular system* Bruit (arterial), Weak pulse
7869	786.9	0	*Other symptoms involving respiratory system and chest* Breath-holding spell
7870	787.0	1	*Nausea and vomiting* Emesis
7876	787.6	1	*Incontinence of feces (excludes that of nonorganic origin)* Incontinence of sphincter ani
7877	787.7	1	*Abnormal feces* Bulky stools (excludes pus, occult blood, abnormal stool color, fat in stool, mucus in stool)
7879	787.9	1	*Other symptoms involving digestive system* Change in bowel habits, Tenesmus (rectal)
33399	333.99	1	*Other and unspecified extrapyramidal diseases and abnormal movement disorders: Other* Restless legs
30001	300.01	0	*Panic disorder* Panic: attack, state
49390	493.9	fuzzy	*Asthma, unspecified* Asthma (bronchial or allergic); Bronchitis: allergic, asthmatic
71659	716.59	1	*Unspecified polyarthropathy or polyarthritis*
71940 71948 71949	719.40 } 719.48 } 719.49 }	fuzzy	*Pain in joint* Arthralgia
71951	719.51	1	*Stiffness of joint, not elsewhere classified*
71960	719.60	0	*Other symptoms referable to joint* Joint creptis, Snapping hip

78000	780.00	fuzzy	*General symptoms* COVERS 780.0 Alteration of consciousness (excluding coma)
78002	780.02	fuzzy	*Transient alteration of awareness*
78999	789.99	0	*Other symptom involving abdomen and pelvis* Umbilical: bleeding, discharge

APPENDIX C:

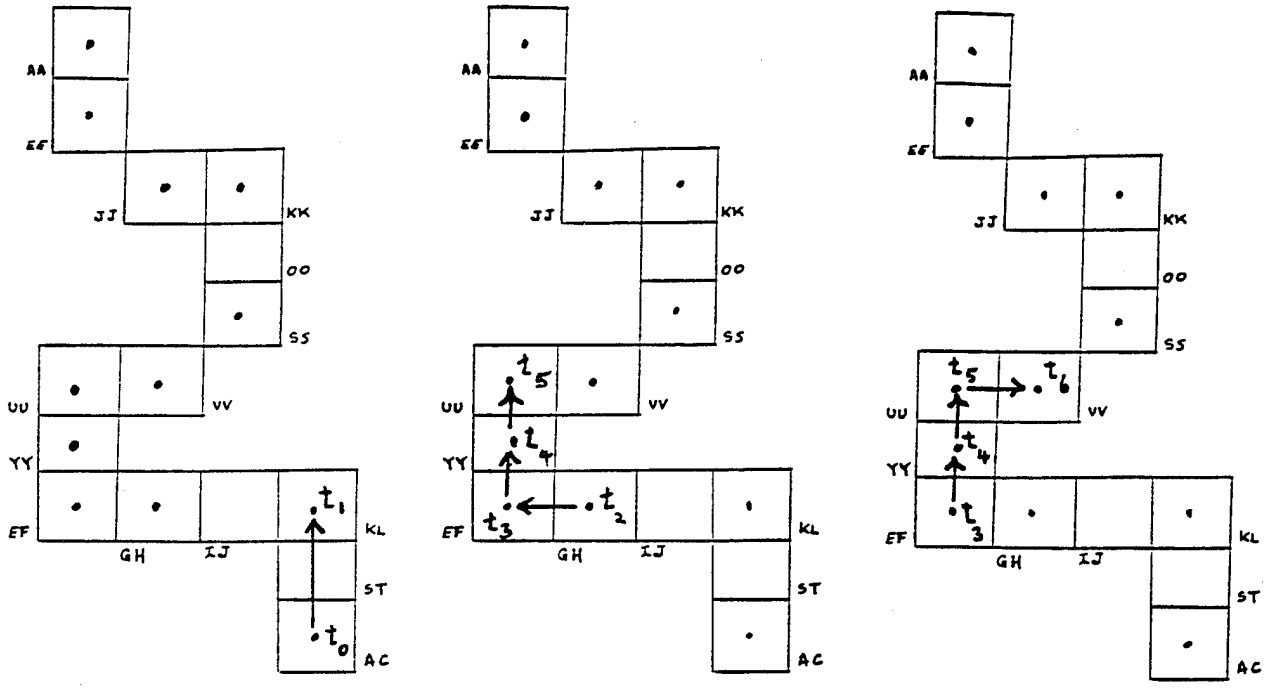
TIMELINE GRAPHIC REPRESENTATION OF COMBAT UNITS
(OR COMBATANTS) AND ITS CORRESPONDENCE TO
ARMY MAP GRIDS ON THE BATTLEFIELD

INTENTIONALLY LEFT BLANK.



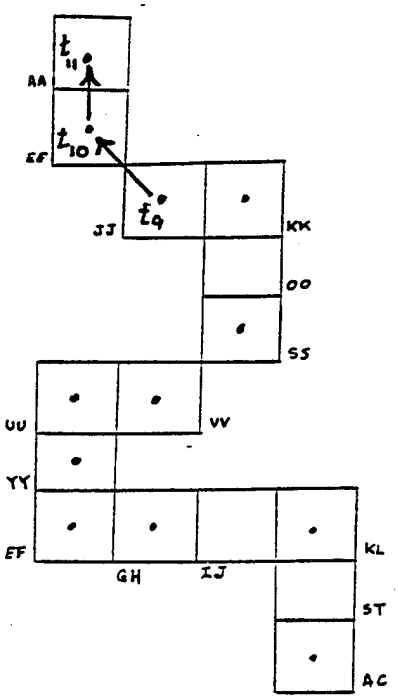
Unit 1

Person 1 Person 2 Person 3

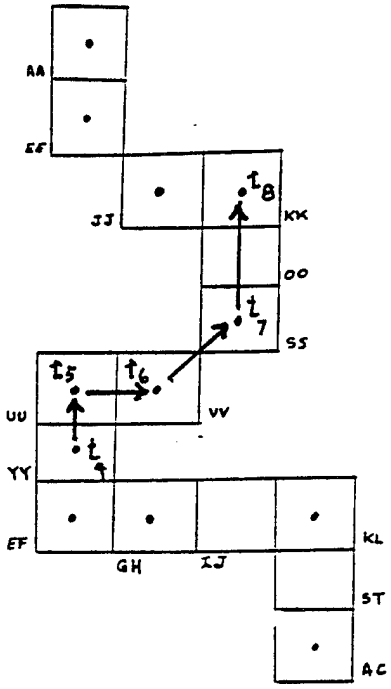


Unit 2

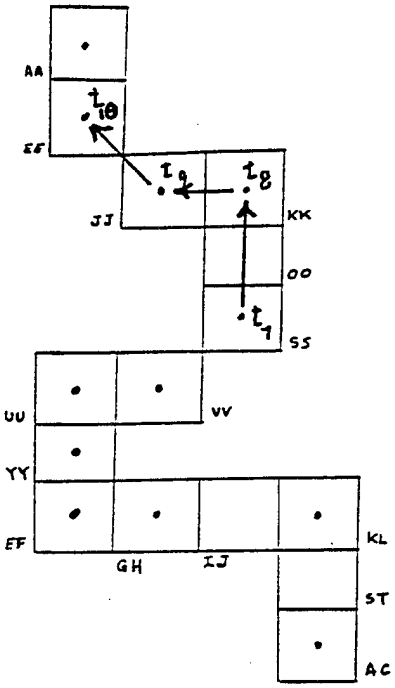
Person 4



Person 5



Person 6



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